FIG. **17** illustrates a 3-D acoustic imaging embodiment of the invention.

THE INVENTION EMBODIMENTS

FIG. **1**

The invention herein and disclosed in portions of other copending applications noted above, comprehends a combination of one or more TV cameras (or other suitable electro-optical sensors) and a computer to provide various position and orientation related functions of use. It also comprehends the combination of these functions with the basic task of generating, storing and/or transmitting a TV image of the scene acquired—either in two or three dimensions.

The embodiment depicted in FIG. **1**A illustrates the basic embodiments of many of my co-pending applications above. A stereo pair of cameras **100** and **101** located on each side of the upper surface of monitor **102** (for example a rear projection TV of 60 inch diagonal screen size) with display screen **103** facing the user, are connected to PC computer **106** (integrated in this case into the monitor housing), for example a 400 Mhz Pentium II. For appearances and protection a single extensive cover window may be used to cover both cameras and their associated light sources **110** and **111**, typically LEDs.

The LEDs in this application are typically used to illuminate targets associated with any of the fingers, hand, feet and head of the user, or objects such as **131** held by a user, **135** with hands **136** and **137**, and head **138**. These targets, such as circular target **140** and band target **141** on object **131** are desirably, but not necessarily, retro-reflective, and may be constituted by the object features themselves (e.g., a finger tip, such as **145**), or by features provided on clothing worn by the user (e.g., a shirt button **147** or polka dot **148**, or by artificial targets other than retroreflectors.

Alternatively, a three camera arrangement can be used, for example using additional camera **144**, to provide added sensitivity in certain angular and positional relationships. Still more cameras can be used to further improve matters, as desired. Alternatively, and or in addition, camera **144** can be used for other purposes, such as acquire images of objects such as persons, for transmission, storage or retrieval independent of the cameras used for datum and feature location determination.

For many applications, a single camera can suffice for measurement purposes as well, such as **160** shown in FIG. **1**B for example, used for simple 2 dimensional (2D) measurements in the xy plane perpendicular to the camera axis (z axis), or 3D (xyz, roll pitch yaw) where a target grouping, for example of three targets is used such as the natural features formed by the two eyes **164**, **165** and nose **166** of a human **167**. These features are roughly at known distances from each other, the data from which can be used to calculate the approximate position and orientation of the human face. Using for example the photogrammetric technique of Pinkney described below, the full 6 degree of freedom solution of the human face location and orientation can be achieved to an accuracy limited by the ability of the camera image processing software utilized to determine the centroids or other delineating geometric indicators of the position of the eyes and nose, (or some other facial feature such as the mouth), and the accuracy of the initial imputing of the spacing of the eyes and their respective spacing to the nose. Clearly if a standard human value is used (say for adult, or for a child or even by age) some lessening of precision results, since these spacings are used in the calculation of distance and orientation of the face of human **167** from the camera **160**.

In another generally more photogrammetrically accurate case, one might choose to use four special targets (e.g., glass bead retro-reflectors, or orange dots) **180**-**183** on the object **185** having known positional relationships relative to each other on the object surface, such as one inch centers. This is shown in FIG. **1**C, and may be used in conjunction with a pixel addressable camera such as described in FIG. **2** below, which allows one to rapidly determine the object position and orientation and track its movements in up to 6 degrees of freedom as disclosed by Pinkney U.S. Pat. No. 4,219,847 and technical papers referenced therein. For example, the system described above for FIGS. **1** and **2** involving the photogrammetric resolution of the relative position of three or more known target points as viewed by a camera is known and is described in a paper entitled "A Single Camera Method for the 6-Degree of Freedom Sprung Mass Response of Vehicles Redirected by Cable Barriers" presented by M. C. van Wijk and H. F. L. Pinkney to The Society of Photo-optical Instrumentation Engineers.

The stereo pair of cameras can also acquire a two view stereo image of the scene as well, which can be displayed in 3D using stereoscopic or auto-stereoscopic means, as well as transmitted or recorded as desired.

In many applications of the foregoing invention it is desirable not just to use a large screen but in fact one capable of displaying life size images. This particularly relates to human scaled images, giving a life-like presence to the data on the screen. In this way the natural response of the user with motions of hands, head, arms, etc., is scaled in "real" proportion to the data being presented.

FIG. **2**

This embodiment and others discloses special types of cameras useful with the invention. In the first case, that of FIG. **2**A, a pixel addressable camera such as the MAPP2200 made by IVP corporation of Sweden is used, which allows one to do many things useful for rapidly determining location of objects, their orientation and their motion.

For example, as shown in FIG. **2**A, an approximately circular image **201** of a target datum such as **180** on object **185** of FIG. **1**C may be acquired by scanning the pixel elements on a matrix array **205** on which the image is formed. Such an array in the future will have for example 1000×1000 pixels, or more (today the largest IVP makes is 512×512. The IVP also is not believed to be completely randomly addressable, which some future arrays will be).

As an illustration, computer **220** determines, after the array **205** has been interrogated, that the centroid "x, y" of the pixel elements on which the target image lies is at pixel x=500, y=300 (including a sub-fraction thereof in many cases). The centroid location can be determined for example by the moment method disclosed in the Pinkney patent, referenced above.

The target in this case is defined as a contrasting point on the object, and such contrast can be in color as well as, or instead of, intensity. Or with some added preprocessing, it can be a distinctive pattern on the object, such as a checkerboard or herringbone.

Subsequent Tracking

To subsequently track the movement of this target image, it is now only necessary to look in a small pixel window composed of a small number of pixels around the target. For example the square **230** shown, as the new position x'y' of the